STUDIES ON SERUM T3, T4, TSH, PROGESTERONE, AND OESTROGEN IN CARDIOVASCULAR DISEASE PATIENTS

ABSTRACT

Aim: This research was done to ascertain if thyroid hormones and female sex hormones (progesterone and estrogen) play a role or are a risk factor in the development of cardiovascular diseases.

Study Design: This is an observational study, specifically a case-control study.

Place and Duration of Study: This study was conducted at Enugu State University Teaching Hospital for six months.

Methodology:Blood samples were collected from 20 persons with cardiovascular disease.The sera from the study subjects were estimated for T_3, T_4, and TSH using the ELISA technique. The same parameters were estimated in 20 healthy individuals, and the results from both groups were analysed using SPSS version 21.

Results: There were no significant differences in serum T3, T4 and TSH, Progesterone and Estradiol (p=0.236, p=0.834, p=0.412, p=0.995 and p=0.512, respectively) in cardiovascular disease patients compared with controls. There were no significant differences in serum T3, Progesterone, Estradiol and TSH (p=0.443, p=0.291, p=0.612 and p=0.550, respectively) in male cardiovascular disease patients compared to female cardiovascular disease patients. There was a significantly higher level of T4 (p=0.042) in male cardiovascular disease patients compared to female cardiovascular disease patients. A significant negative correlation of serum TSH with T4 (r=-0.759, p=0.000) in cardiovascular disease patients. There was no significant correlation of serum TSH with T3 (r=-0.131, p=0.560) in cardiovascular disease patients. There was a significant positive correlation of Serum Progesterone with Estradiol (r=0.815, p=0.000) in cardiovascular disease patients.

Conclusion: T4, T3, and TSH serum levels may not be associated with the development of cardiovascular diseases in this environment. Also, serum progesterone may have a linear association with estradiol in cardiovascular disease patients.

Keywords: Heart disease, sex hormones, thyroid hormones, pituitary gland, menopause

INTRODUCTION

Cardiovascular disease (CVD) is a class of diseases involving the heart or blood vessels. Cardiovascular disease includes coronary artery diseases (CAD) such as angina and myocardial infarction (commonly known as a heart attack), stroke, heart failure, hypertensive heart disease, rheumatic heart disease, cardiomyopathy, heart arrhythmia, congenital heart disease, and others [1].The thyroid hormones(thyroxine and triiodothyronine) are tyrosine-based hormones that are produced by the thyroid gland, which are primarily responsible for the regulation of metabolism, with thyroxine (T_4) being the primary form found in the blood and has a higher shelf life [2].Thyrotrophin (Thyroid Stimulating Hormone) is a glycoprotein hormone synthesised and released by the pituitary gland that regulates the endocrine function of the thyroid gland [3].

Gender has an essential influence on cardiovascular disease, with premenopausal women having lower arterial blood pressure than age-matched men. Compared with premenopausal women, postmenopausal women have higher blood pressures, suggesting that ovarian hormones such as estrogen (estradiol, which is the biologically active form in the blood) and progesterone may modulate the risk of heart disease[4]. Research has shown that female sex hormones play an essential role in cardiovascular pathophysiology and that there are significant sex differences in cardiovascular risk[5].Some research has it that the level of progesterone and estrogen plays a vital role in the reduction of cardiovascular diseases in women. However, the authenticity of the information still needs to be questioned.Also, little is known about the association between thyroid function/dysfunction and the risk of cardiovascular diseases. Despite the various research on cardiovascular diseases, the knowledge of the involvement of thyroid and female sex hormones (progesterone and estrogen) remains limited. Hence, this research was done to ascertain if thyroid hormones and female sex hormones (progesterone and estrogen) play a role or are a risk factor in the development of cardiovascular diseases.

MATERIALS AND METHOD

Study Design

The period of subjects' enrolment, classification administration of questionnaires, sample collection, determination of T_4, T_3, TSH, estrogen, and progesterone, and data generation in this study lasted from November 2017 to July 2018. The study area is Enugu state. The study area serves as the major medical clinic for the poor and rich in Enugu state and its environs.

Study Population

By random sampling, 20 cardiovascular disease subjects (10 males and 10 females) between 40 and 60 years were selected. They were age-matched with 20 non-cardiovascular disease subjects (10 males and 10 females) who were the control subjects.

The Selection Criteria for Patients

Inclusion Criteria for Patients

Patients who manifested a familyhistory of heart failure, Dyspnea (Shortness of breath), and vascular congestionwere revealed by chest radiography. Angina pectoris, Rapid/irregular Pulse rate. Electrolyte, Urea, and Creatinine laboratory reports establish mild to moderate renal insufficiency and oedema in the legs (ankles and feet). Electrocardiogram changes, abnormal echocardiogram report, Fatigue and weakness, exercise intolerance, Persistent cough or wheezing with white or blood-stained mucus/catarrh.

Exclusion

Exclusion criteria are as follows: Patients who manifested some chronic disease such as HIV/AIDS, liver diseases (hepatitis), Diabetes mellitus/insipidus, and tuberculosis. Subjects without any clinical manifestation of heart disease are healthy individuals. Patients outside the age range for this study. Subjects who refused to give informed consent for this study.

Sample Collection

Five millilitres of venous blood collected from each participant was dispensed into a plain container and centrifuged at 3000 rpm for 10 minutes. The serum was extracted into plain containers and stored refrigerated at -20 till analysis. All samples were analysed within four days of sample collection.

Estimation of the levels of serum T_3, T_4, and TSH

A microplate reader model MR-96A (Operon Bio Tech and Health care, Koramangala, Bengaluru,India) was employed for serum T_3, T_4,and TSH determination as previously described byGharib and Chopra for T_3[6, 7], Barker and Chopra for T_4[7, 8], Hopton and Caldwell for TSH[9, 10]. Serum progesterone and estradiol were also determined using the same microplate reader described by RadwanskaandMuotila[11, 12], respectively. The digested samples were analysed usingthe ELISA methodology, and readings were taken. Repeated analyses of standard solutions confirmed the method's precision.

Statistical Analysis

SPSS version 21 was employed in the statistical analysis of the data obtained. The test of significance was determined by student t-test and Pearson Correlation. Values with $P< 0.05$ were considered statistically significant. All values were expressed as mean ± standard deviation.

RESULTS

Table 1: There were no significant differences in serum T_3, T_4, and TSH, Progesterone, and Estradiol (p=0.236, p=0.834, p=0.412, p=0.995 and p=0.512 respectively) in cardiovascular disease patients compared with controls.

Table 1: Serum T_3, T_4, TSH, Progesterone and Estradiol in Cardiovascular Disease Patients versus Controls

VARIABLE	Cardiovascular Disease	Controls (n=20)	t-value	p-value

(Mean ± SD	(n=20)			
T_3 (ng/ml)	1.80±0.33	1.58±0.59	1.224	0.236
Lower 95% C.I.	1.64	1.30		
Upper 95% C.I.	1.95	1.85		
T_4 (μg/dl)	11.02±2.72	10.83±3.0	0.212	0.834
Lower 95% C.I.	9.74	9.41		
Upper 95% C.I.	12.29	12.24		
TSH(μIU/mL)	1.74±0.61	1.92±0.92	-0.838	0.412
Lower 95% C.I.	1.45	1.48		
Upper 95% C.I.	2.02	2.35		
Progesterone(pg/ml)	1.50±3.44	1.49±2.55	0.007	0.995
Lower 95% C.I.	-0.11	0.29		
Upper 95% C.I.	3.11	2.69		
Estradiol(pg/ml)	75.94±28.68	70.23±35.58	0.669	0.512
Lower 95% C.I.	62.51	53.57		
Upper 95% C.I.	89.36	86.89		

Table 2: There were no significant differences in serum T_3, Progesterone, Estradiol and TSH (p=0.443, p=0.291, p=0.612 and p=0.550, respectively) in male cardiovascular disease patients compared to female cardiovascular disease patients.There was a significant higher level of T_4 (p=0.042) in male cardiovascular disease patients compared to female cardiovascular disease patients.

Table 2: Serum T_3, T_4, TSH, Progesterone and Estradiol in Male Cardiovascular Diseases Patients versus Female Cardiovascular Diseases Patients

VARIABLES (Mean ± SD)	Male Cardiovascular Disease Patients (n= 10)	Female Cardiovascular Disease Patients (n=10)	t-value	p-value
T_3 (ng/ml)	1.75±0.45	1.86 ±0.14	-0.803	0.443
Lower 95% C.I.	1.41	1.75		
Upper 95% C.I.	2.06	1.96		
T_4 (μg/dl)	9.40±2.40	12.84±2.01	-2.372	0.042
Lower 95% C.I.	7.69	11.20		
Upper 95% C.I.	11.11	14.07		
TSH (μIU/mL)	1.90±0.54	1.54±0.66	1.121	0.291
Lower 95% C.I.	1.50	1.10		
Upper 95% C.I.	2.29	2.05		
Progesterone(pg/ml)	1.94±4.93	1.18±0.56	0.525	0.612
Lower 95% C.I.	-1.57	0.77		
Upper 95% C.I.	5.47	1.59		
Estradiol (pg/ml)	77.27±39.39	70.64±13.37	0.621	0.550
Lower 95% C.I.	49.09	61.07		
Upper 95% C.I.	105.45	80.21		

Table 3: A significant negative correlation of serum TSH with T_4 (r=-0.759, p=0.000) in cardiovascular disease patients. There was no significant correlation of serum TSH with T_3 (r=-0.131, p=0.560) in cardiovascular disease patients.

Table 3: Correlation of Serum TSH with T_3 and T_4 in Cardiovascular Disease Patients

Dependent variables	N	r- value	p-value
T_3	**20**	**-0.131**	**0.560**
T_4	**20**	**-0.759****	**0.000**
Progesterone	**20**	**-0.488***	**0.029**
Estradiol	**20**	**-0.464***	**0.039**

Table 4: In cardiovascular disease patients, there was a significant positive correlation of Serum Progesterone with Estradiol (r=0.815, p=0.000).

Table 4: Pearson Correlation of Serum Progesterone with Estradiol in Cardiovascular Disease Patients

Dependent variables	N	r-value	p-value
Estradiol	20	0.994**	0.000
T3	20	0.108	0.649
T4	20	0.403	0.078

DISCUSSION

Cardiovascular diseases are abnormal issues affecting the heart and blood vessels [13]. The development of this disease condition is multi-factorial, with a higher risk of cardiovascular disease than pre-menopausal women [14]. This study revealsno significant differences in serum T_3, T_4, TSH, progesterone and estradiol in cardiovascular disease patients compared to controls. This could be because ofthe absence of thyroid dysfunction in the patients. It was found that thyroid function in the clinically normal range was not associated with cardiovascular disease.

In contrast, it was reported that a higher serum concentration of T_3 and T_4 and lower TSH were found in patients suffering from cardiovascular disease (called subclinical hyperthyroidism) [15].In a 10-year cohort study of older patients, a low TSH was associated with an increased risk for cardiovascular mortality [16] and atrial fibrillation [17]. Thyroid dysfunction is one of the risk factorsfor cardiovascular disease [18]. T_3 increases the heart rate and force of contraction, thus increasing cardiac output by increasing β-adrenergic receptor levels in the myocardium [19]. This results in increased systolic blood pressure and decreased diastolic blood pressure. A low TSH level is associated with an increased risk for atrial fibrillation, which in turn could lead to congestive heart failure [20]. Hyperthyroidism is characterised by widened pulse pressure.

Recent reports have shown that arterial stiffness is increased in hyperthyroidism despite the low systemic vascular resistance (SVR) [21].Thus, excess thyroid hormone typically causes systolic blood pressure to rise, which can be quite dramatic in older patients with impaired arterial compliance due to atherosclerotic disease. Hyperthyroidism, the most common form of hypertension, has been documented as a secondary cause of isolated systolic hypertension [22]. In hypothyroidism, endothelial dysfunction and impaired vascular smooth muscle cells (VSM) relaxation led to increased SVR [23]. These effects lead to diastolic hypertension in 30% of patients [24].Also, no significant difference in serum progesterone and estradiol of cardiovascular disease patients compared to control is similar to the research carried out by Wehr*et al*. [25]; they found no significant change in estradiol and progesterone levels due to the cardiac arrest and resuscitation process in a canine model of ventricular fibrillation arrest. Epidemiological studies have linked lower androgen levels with a higher risk of cardiac disease; however, whether there is a causal role remains unclear [26].

This study showed no significant differences in serum T_3, TSH, progesterone, and estradiol in male heart disease patients compared to female heart disease patients. There was a significantly higher level of T_4 in male heart disease patients compared to female heart disease patients. T_4 is converted to the active T_3 within cells by deiodinases (5'-iodine). The changes in deiodinase 1 and 2 catalytic properties are higher in subjects with higher fat mass, leading to a higher conversion of T_4 to T_3[27]. Since females have higher adipose tissue than males, an increased level of deiodinases 1 in adipose tissue stimulates it, leading to leptin production. In turn, it enhances the production of T_3 from T_4[27]. This could explain the higher level of T4 in males than females. No significant difference in serum progesterone and estradiol suggests that the level of progesterone and estradiol is not a predictive factor in diagnosing any form of heart disease. It is in agreement with a recent analysis of cardiovascular diseases in a large cohort of postmenopausal women with regards to the female sex hormones, which showed no clear relationship between the level of estradiol and progesterone and the incidence of cardiovascular diseases [28].Female sex hormones were considered to play an essential role in reducing the incidence of cardiac disease in pre-menopausal women. However, the large cohort trials showed no benefit of combined estrogen/progesterone supplementation and possible harm with a greater risk of cardiovascular disease [29]. This raises the question of whether either of these hormones has potentially harmful effects.

This present study showed a significant negative correlation of serum TSH with T_4 in cardiovascular disease patients. This means serum TSH increases as T_4 decreases in cardiovascular disease patients [15, 30]. This was also mentioned by Johansen et al. in their research, in which there was a significant negative correlation of serum TSH with T_4[31]. The negative feedback mechanism could explain this. Production of T_3 and its prohormone thyroxine (T_4) is activated by thyroid-stimulating hormone (TSH), which is released from the anterior pituitary gland. This pathway is part of a closed-loop feedback process. Elevated concentrations of T_3 and T_4 in the blood plasma inhibit the production of TSH in the anterior pituitary gland. As concentrations of these hormones decrease, the anterior pituitary gland increases production of TSH. By these processes, a feedback control system stabilises the amount of thyroid hormones in the bloodstream [32].Serum TSH with T3 in cardiovascular disease patients had no significant correlation.

In contrast, Johansen et al. reported a significant correlation of serum TSH with T_3. Still, they later stated that the correlation coefficients dropped to non-significant levels when partial correlation analysis considered and eliminated interdependence between the T3 and T4 indices [31].There was a significant positive correlation between serum progesterone and estradiol, indicating a linear relationship between progesterone and estradiol levels in cardiovascular diseases.

Conclusion

Thyroid dysfunction affects the heart either by producing too little thyroid hormone (a condition called hypothyroidism) or too much thyroid hormone (called hyperthyroidism). Thyroid dysfunction is a risk factor for cardiovascular disease. Thyroid function in the clinically normal range is not associated with cardiovascular disease. Hence, this study concludes that serum T4, T3, and TSH levels may not be related tothe development of cardiovascular diseases in this environment.This study also concludes that serum progesterone may have a linear association with estradiol in cardiovascular disease patients.

Ethical Approval and Consent

The Ethical Advisory Committee of Enugu State University Teaching Hospital (ESUTH) approved the research protocol. Informed consent and approval of all the subjects were obtained. Each participant signed a consent form after the procedure, and implementations were explained to the subject in English or the local Igbo dialect. Participation was voluntary, and participants could withdraw from the study at any time.

REFERENCES

1. McGill H.C., McMahan, C.A. and Gidding, S.S. (2008). Preventing heart disease in the 21st century: implications of the Pathobiological Determinants of Atherosclerosis in Youth (PDAY) study. *Circulation*. 117 (9):1216–1227.
2. Irizarry and Lisandro (2014). Thyroid Hormone Toxicity. Medscape.WedMD LLC. Retrieved on 18-02-2018. From https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Triiodothyronine.html.
3. Sacher, R., Richard, A. and McPherson (2000). Widmann's Clinical Interpretation of Laboratory Tests, 11th ed. F.A. Davis Company. ISBN 0-8036-0270-7.
4. Raghvendra, K., Suzanne, O. and Edwin, k. (2002). *Cardiovascular Research* 53 (3): 688-708
5. Murray, C.J., Vos, T. and Lozano, R. (2010). Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: A systematic analysis for the global burden of disease study 2010. *Lancet*. 380:2197–2223.
6. Gharib, H., Ryan, R.J., Mayberry, W.E. and Hockett, T. (1971). Radioimmunoassay for Triiodothyronine (T_3): Affinity and Specificty of Antibody for T_3. *Journal of Clinical Endocrinology* 33:509.
7. Chopra I.J., Ho R.S. and Lam, R. (1971). Immunoassay of triiodothyronine in human serum. *Journal of Laboratory Clinical Medicine* 80:729.
8. Barker S.B. (1948). Determination of protein bound iodine. *Journal of Biological Chemistry* 173:175.

9. Hopton, M.R. and Harrap, J.J. (1986). Immunoradiometric assay of thyrotropin as a first line thyroid function test in the routine laboratory.*Clinical Chemistry* 32: 691.
10. Caldwell, G *et al.* (1985). A new strategy for thyroid function testing. *Lancet* 1: 1117.
11. Radwanska, E., Frankenbery, J. and Allene. (1978). Plasma progesterone levels in normal and abnormal early human pregenacy,fertility and sterility 30: 398-402.
12. Muotila,E., Ruoslahti, E. and Engvall. (1981).Two-site sandwich enzyme immunoassay with monoclonal antibodies to human alpha-fetoprotein.*Journal of Immunological Methods.* ELISA 42(1): 11-15.
13. Nguyen, R. (2013). Long-term trends in the incidence of and survival with heart failure.*National England Journal of Medicine.*347:1397–1402.
14. Finegold, J.A., Asaria, P., and Francis, D.P. (2012). Mortality from ischaemic heart disease by country, region, and age: Statistics from World Health Organisation and United Nations". *International Journal of Cardiology*. 168 (2): 934–945.
15. Demers, L.M. and Spencer, C.A. (2003) Laboratory medicine practice guidelines: laboratory support for the diagnosis and monitoring of thyroid disease. *Thyroid* 13:3–126.
16. Parle, J.V., Maisonneuve, P., Sheppard, M.C., Boyle, P. and Franklyn J.A. (2001). Prediction of all cause and cardiovascular mortality in elderly people from one low serum thyrotropin result: a 10-year cohort study. *Lancet* 358:861–865.
17. Sawin, C.T., Geller, A., Wolf P.A., Belanger A.J., Baker, E., Bacharach, P., Wilson, P.W., Benjamin, E.J. and D'Agostino. R.B. (1994). Low serum thyrotropin concentrations as a risk factor for atrial fibrillation in older persons. *The New England Journal of Medicine* 331:1249–1252.
18. Walsh, J.P., Bremner, A.P., Bulsara, M.K., and *et al*. (2005). Thyroid dysfunction and serum lipids: a community-based study. *Clinical Endocrinology* 63:670-675.
19. Cooper, D.S. (1989). "Thyroid hormone treatment: new insights into an old therapy". *JAMA: The Journal of the American Medical Association* 261 (18): 2694–2695.
20. Frost, L., Vestergaard, P. and Mosekilde, L. (2004). Hyperthyroidism and risk of atrial fibrillation or flutter: a population-based study. *Arch Internal Medicine* 164:1675–1678.
21. Palmieri, E.A., Fazio, S., Palmieri, V., Lombardi, G. and Biondi, B. (2004). Myocardial contractility and total arterial stiffness in patients with overt hyperthyroidism: acute effects of beta1-adrenergic blockade. *European Journal of Endocrinology* 150:757–762.
22. Prisant, L.M., Gujral, J.S. and Mulloy, A.L. (2006). Hyperthyroidism: a secondary cause of isolated systolic hypertension. *Journal of Clinical Hypertension* 8:596–599.
23. Napoli, R., Biondi, B., Guardasole, V., Matarazzo, M., Pardo, F., Angelini, V., Fazio, S. and Sacca, L. (2001). Impact of hyperthyroidism and its correction on vascular reactivity in humans.*Circulation*104:3076–3080.
24. Taddei, S., Caraccio, N., Virdis, A., Dardano, A., Versari, D., Chiadoni, L., Salvetti, A., Ferrannini, E. and Monzani, F. (2003). Impaired endothelium-dependent vasodilatation in subclinical hypothyroidism: beneficial effect of levo-thyroxine therapy. *Journal of Clinical Endocrinology Metabolism* 88:3731–3737.
25. Wehr, E., Pilz, S., Boehm, B.O., Marz, W., Grammer, T., Obermayer-Pietsch, B. (2011). Low free testosterone is associated with heart failure mortality in older men referred for coronary angiography. *European Journal of Heart Failure*. 13:482–488.
26. Thijs, L., Fagard, R., Forette, F., Nawrot, T., Staessen, J.A. (2013). Are low dehydroepiandrosteronesulphate levels predictive for cardiovascular diseases? A review of prospective and retrospective studies. *Actartica Cardiology*. 58:403–410.

27. Ortega, F.J., Jilkova, Z.M., Moreno-Navarrete, J.M. and *et al*. (2012). Type 1 iodothyronine 5'-deiodinase mRNA and activity is increased in adipose tissue of obese subjects. *International Journal of Obesity* 36:320-324.
28. Bertoia, M.L., Allison, M.A., Manson, J.E., Freiberg, M.S., Kuller, L.H., Solomon, A.J., Limacher, M.C., Johnson, K.C., Curb, J.D., Wassertheil-Smoller, S. and Eaton, C.B. (2012). Risk factors for sudden cardiac death in post-menopausal women.*Journal of America Cardiology*. 60:2674–2682.
29. Manson, J.E., Hsia, J., Johnson, K.C. (2004). Women's Health Initiative I. Estrogen plus progestin and the risk of coronary heart disease. *National England Journal of Medicine.*349:523–534.
30. Surks M.I., Ortiz, E., Daniels G.H., Sawin, C.T., Col, N.F., Cobin, R.H., Franklyn, J.A., Hershman, J.M., Burman, K.D., Denke, M.A., Gorman, C., Cooper, R.S. and Weissman, N.J. (2004). Subclinical thyroid disease: scientific review and guidelines for diagnosis and management. *JAMA* 291:228–238
31. Johansen, K., and *et al*., (1978). The relationship between levels of thyroid stimulating hormone and of thyroxine and triiodothyronine in blood of hypothyroid patients. *Journal of Acta Endocrinology* 88:691-697.
32. Bowen, R. (2010). Physiologic Effects of Thyroid Hormones.*Colorado State University. Retrieved 2018-04-29. From* https://www.revolvy.com/page/Triiodothyronine.